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CONTRACT TECHNICAL NOTE

CW RADAR FOR MEASURING HEAD-ON RADAR CROSS SECTION OF FREE-FLIGHT PROJECTILES

I. Antenna for Simultaneous 35 and 70Gc Operation

P.E. ROBILLARD and W.E. BLORE

CONTRACT NO. DA-04-495-ORD-3567(Z)
HYPERVELOCITY RANGE RESEARCH PROGRAM
A PART OF PROJECT "DEFENDER"

GM DEFENSE RESEARCH LABORATORIES

SANTA BARBARA, CALIFORNIA

AEROSPACE OPERATIONS DEPARTMENT

CTN64-01

JULY 1964

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P.E. ROBILLARD and W.E. BLORE

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JULY 1964

CW RADAR FOR MEASURING HEAD-ON

RADAR CROSS SECTION OF FREE-FLIGHT PROJECTILES

I. ANTENNA FOR SIMULTANEOUS 35 AND 70 Gc OPERATION

(P. E. ROBILLARD AND W. E. BLORE)

A multiplex antenna ~~has been~~ designed for the 35 Gc and 70 Gc radars. This antenna system ~~has now been~~ installed on the physics range to obtain simultaneous measurements of the nose-on radar cross section of hypersonic projectiles.

The 35 Gc and 70 Gc CW Doppler radars ~~have been~~ used alternately on the physics range to measure the nose-on radar cross section of projectiles[1]. The absorption effect previously reported[2] has been measured with this instrumentation. Due to the high cost of firings, simultaneous operation of the two radars would be desirable. In addition, simultaneous observation of radar absorption at two frequencies would provide a more precise comparison than if observations were made on two separate firings.

To measure nose-on radar cross section, the axis of the radar antenna beam must coincide with the flight axis of the projectile. To operate two radars simultaneously means that the two radar beams must be coaxial. Since CW systems were being used and are to be preferred for a variety of reasons, time sharing techniques were not considered. Therefore an antenna system had to be devised which would orient two CW beams coaxially with a minimum of interaction between the two systems.

Design of Multiplex Antenna

The coaxial 35 Gc and 70 Gc radar beams are obtained by using a wire grid[3]. The layout of the antenna system is shown in Fig. 1.

The 35 Gc and 70 Gc antennas are oriented with their axes in the horizontal plane, so that the beams from the two antennas intercept at right angles. At the point of interception a wire grid is located in the vertical plane at 45° to each beam. The wires of the grid are positioned horizontally. The electric vector of the 35 Gc signal is also oriented horizontally (parallel to the grid wires). By choosing a suitable wire diameter and wire spacing, most of the 35 Gc signal is reflected by the grid [4]. The electric vector of the 70 Gc signal is oriented perpendicular to the grid wires. This signal is transmitted through the grid along the same axis as the 35 Gc signal. The dimensions of the two beams at the grid are much smaller than the grid.

The diameter of the grid wires is .025 inches and the wires are uniformly spaced at 0.100 inch centers. The transmission of the 35 Gc (λ = 0.338 in) beam through this grid was expected to be 12.0 db down from the incident signal. Excellent transmission of the 70 Gc (λ = 0.169 in) beam was expected since the wire spacing is approximately $\frac{\lambda}{2}$.

Results

Far field patterns of 35 Gc and 70 Gc antennas were taken. The wire grid and the two antennas were set on a pedestal. The pedestal was rotated to obtain the transmission and reflection patterns of each antenna with the wire grid.

The patterns of the 35 Gc antenna are shown in Fig. 2. The signal transmitted through the grid is 13 db below the signal reflected by the grid (95% reflected). This is 1.0 db lower than predicted. The beam width and sidelobe levels are the same as would be obtained from the antenna without the grid. The antenna used was 10 λ diameter conical horn. The E-plane pattern is shown in Fig. 2.

The transmission and reflection patterns of the 70 Gc system are shown in Fig. 3. The reflection from the grid is 16.0 db below the transmission (97.5% transmitted). Since this is an H-plane pattern of a 20 λ diameter conical horn, the sidelobe level is below the sensitivity of the recorder use. Insertion loss of the grid at the two frequencies is less than 0.2 db.

The most likely source of interaction between the two radars is 70 Gc signal getting into the 35 Gc radar. This can be either a high level 70 Gc signal coupled directly between the two antennas which will bias the 35 Gc mixer crystals or a low level signal which will mix with the 35 Gc local

oscillator. Since the 70 Gc signal radiated by the 70 Gc antenna is reflected by the grid away from the 35 Gc, antenna, it is very unlikely that high level 70 Gc signals will couple into the 35 Gc radar. The most possible source of interaction is from 70 Gc signal returning towards the radar from a target. Fig. 3 shows that the 70 Gc reflected by the wire grid towards the 35 Gc antenna is 16.0 db below the received. Assuming equal 35 Gc and 70 Gc signals returned from the target, the 70 Gc signal reflected towards the 35 Gc antenna is 2.5% of the 35 Gc signal. The interaction of the 70 Gc signal is greatly reduced since the conservion loss of the 70 Gc signal in the 35 Gc mixer is high. Since the leakage signals are evidently low, the interaction between the two radars can be effectively eliminated by off-setting the two radar frequencies. Interaction of the 35 Gc radar with the 70 Gc radar is not possible since 35 Gc signal does not propagate in 70 Gc waveguide (RG/98U).

A photograph of the 35 Gc and 70 Gc multiplex antenna is shown in Fig. 4. The two conical horns and wire grid are shown. A photograph of the two microwave heads are shown in Fig. 5.

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2. The Radar Absorption Effect Measured in a Flight Physics Range, H. M. Musal, Jr., P. E. Robillard and R. I. Primich, TR62-209B, December 1962.

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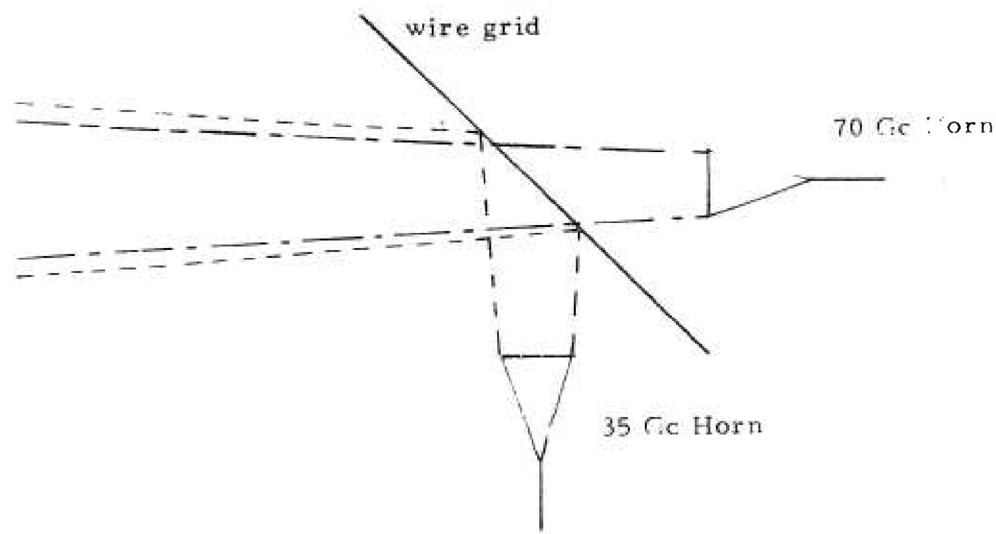


Figure 1   35 Gc & 70 Gc Wire Grid Multiplex Antenna

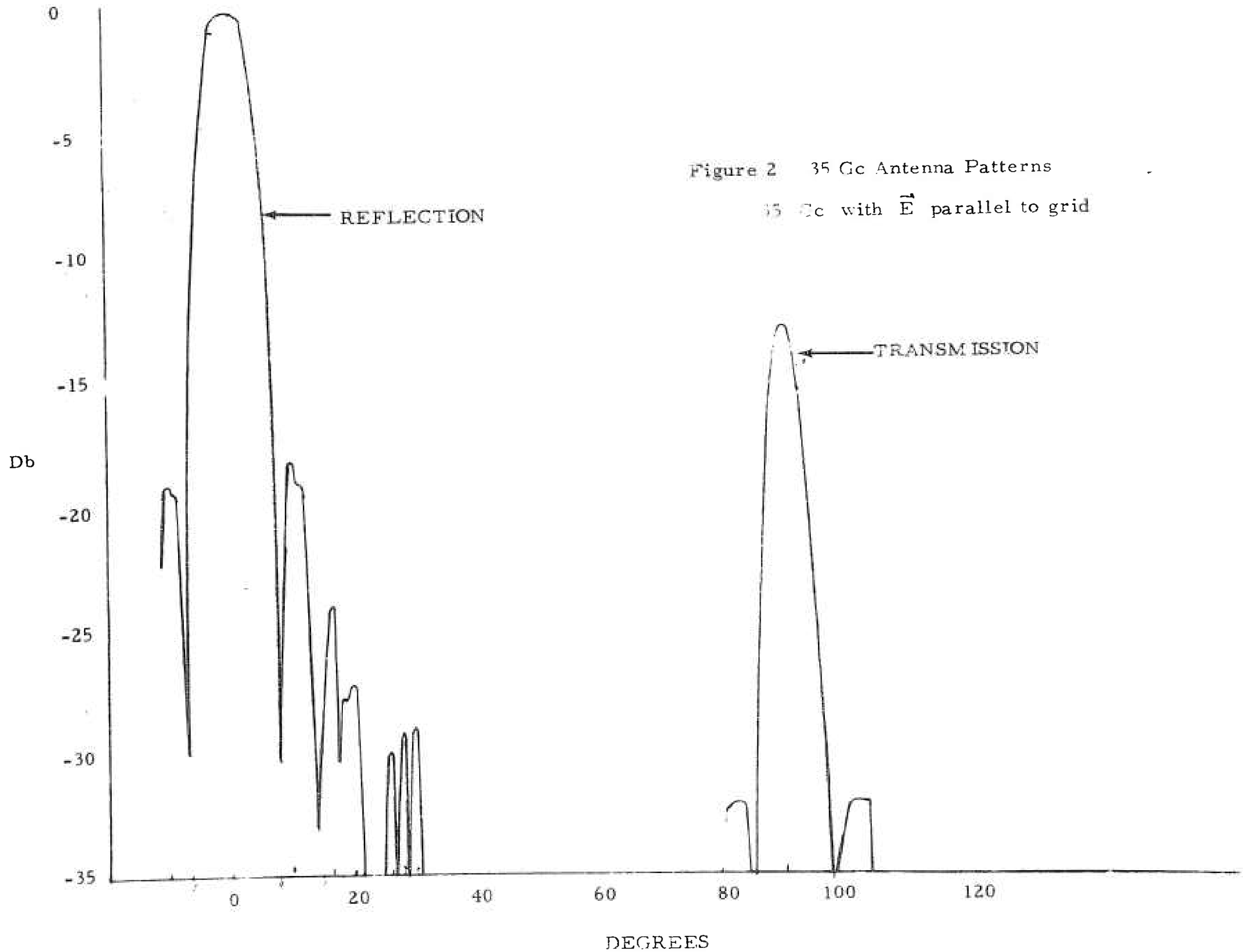


Figure 2 35 Gc Antenna Patterns

35 Gc with $\vec{E}$ parallel to grid

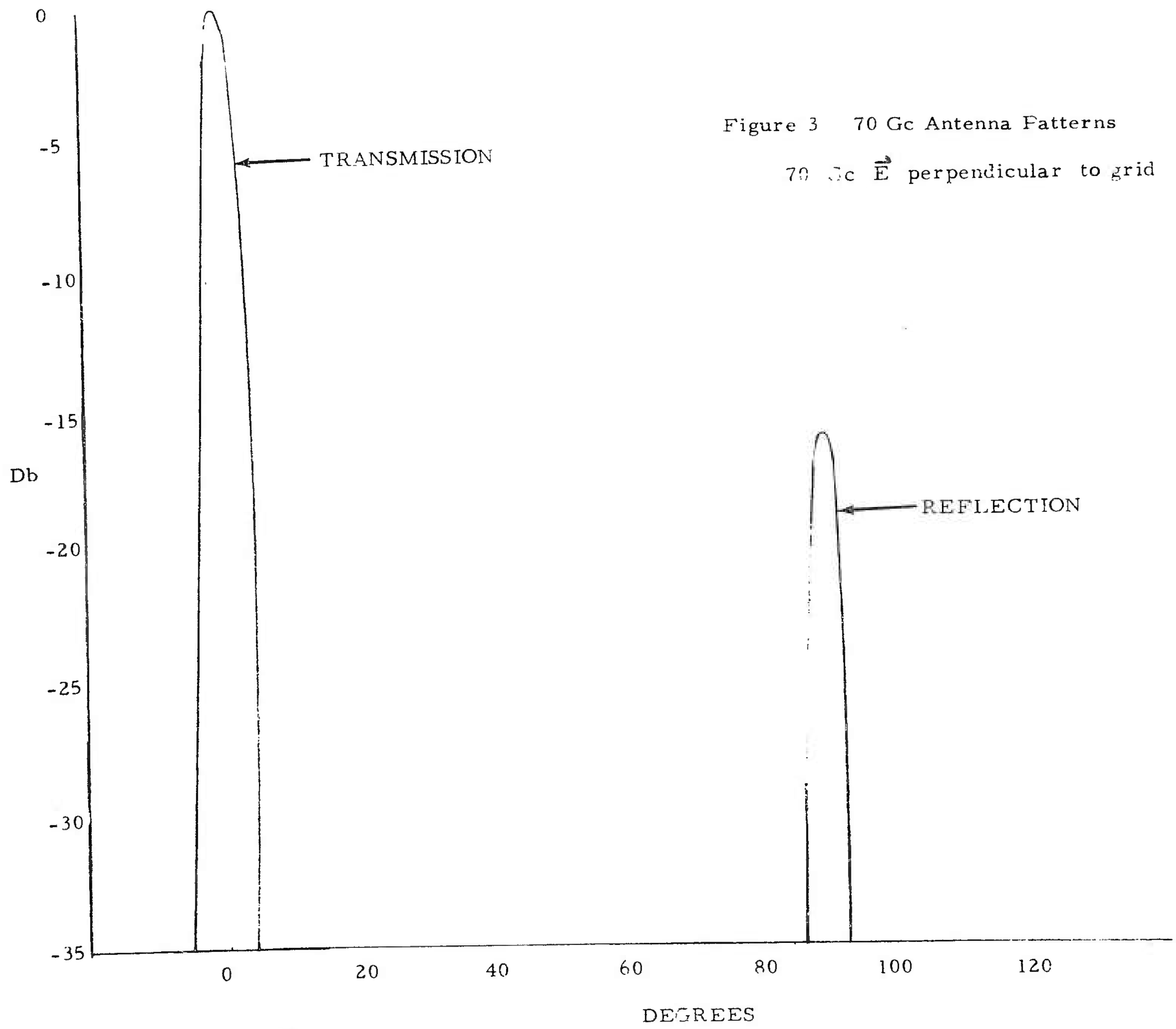


Figure 3 70 Gc Antenna Patterns

70 Gc $\vec{E}$ perpendicular to grid

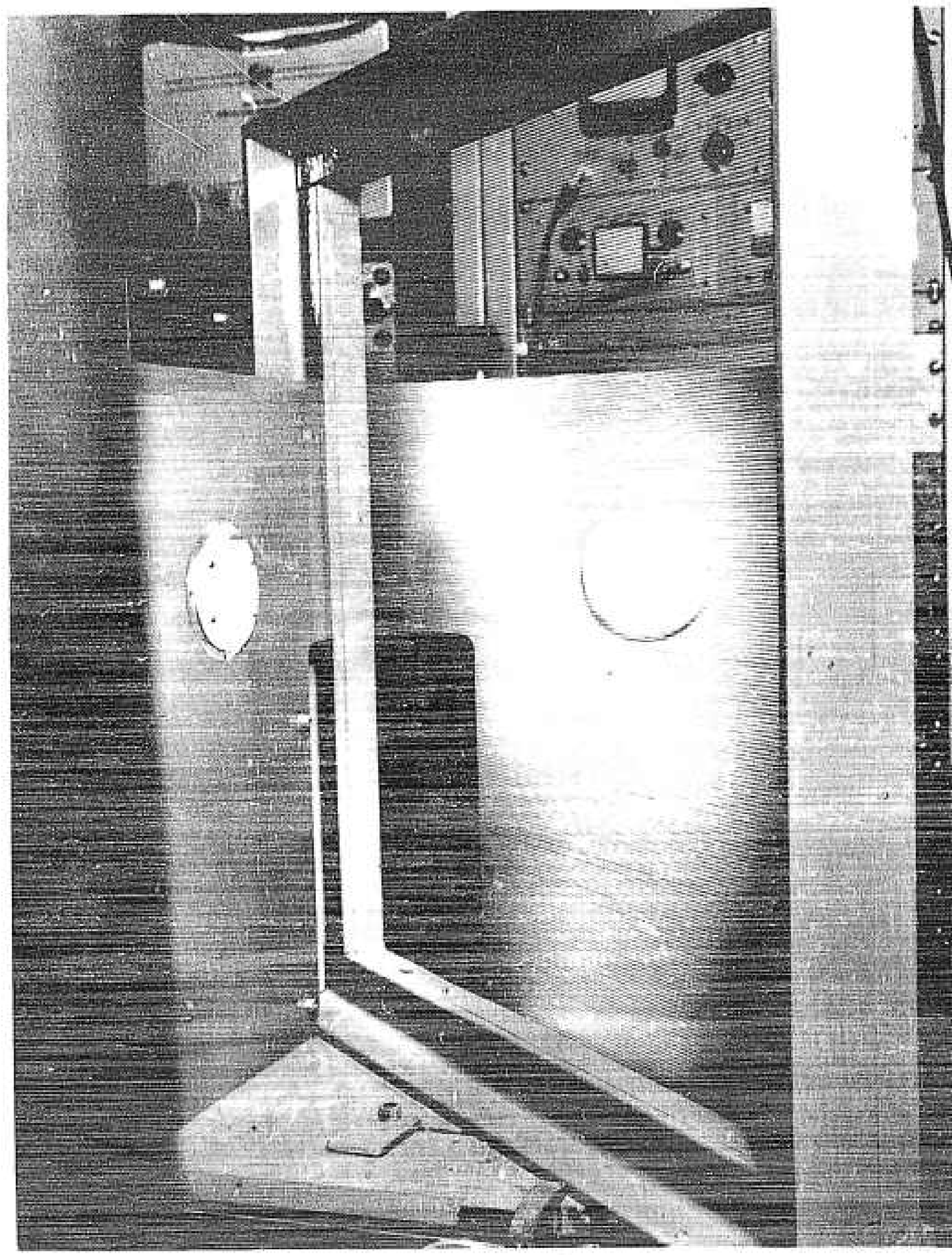
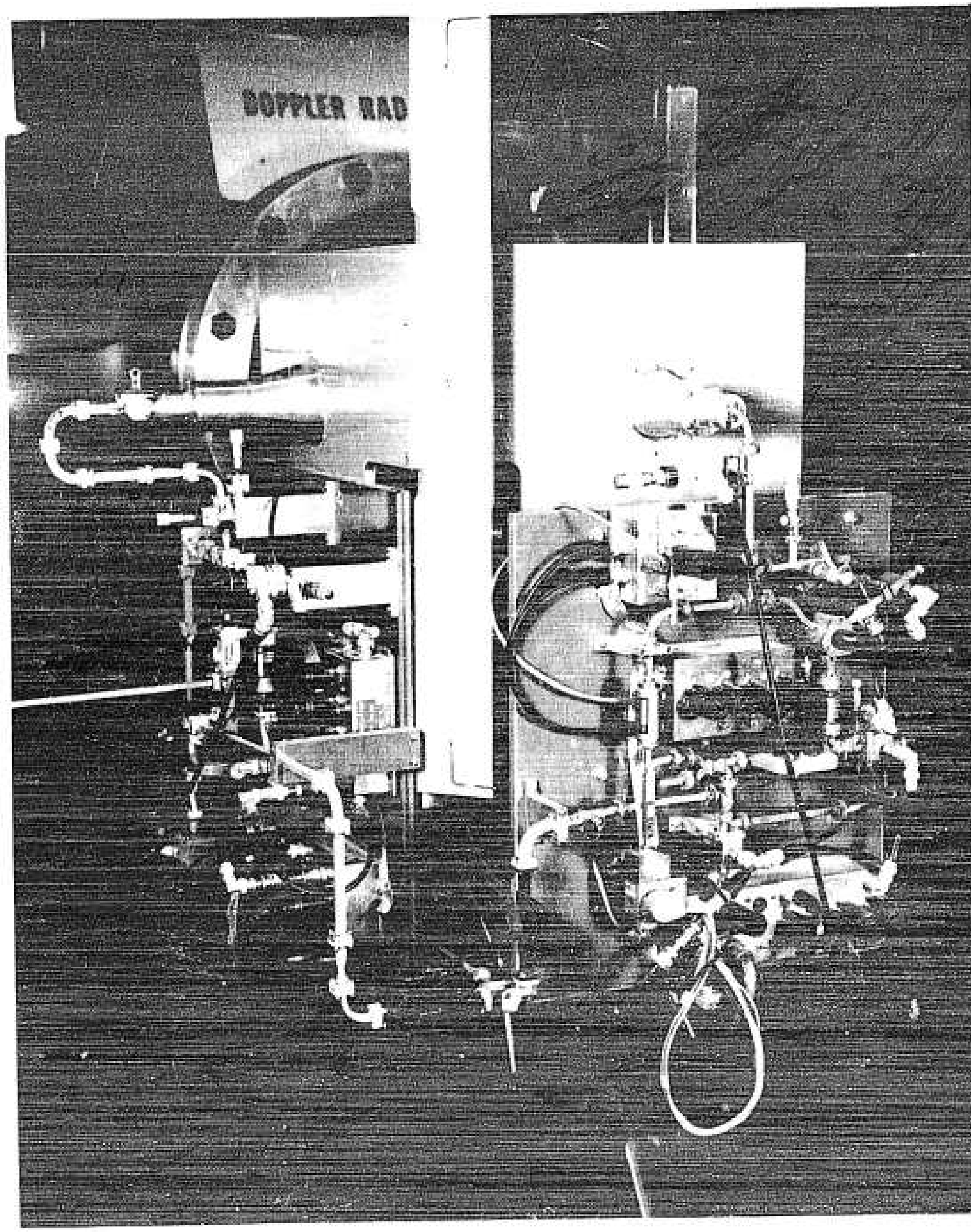


Figure 4



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